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THE COMMERCIAL FREEZING AND STORING OF FISH.

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FREEZING AS A MEANS OF CONSERVING THE FISH SUPPLY.

But for the fact that fish can be frozen and held in storage for months without important change in food value or flavor vast quantities of fish would go to waste, and this valuable nitrogenous food and substitute for meat would be scarce or even unobtainable, except in the smoked, salted, or canned form, during a large part of the year. The additional fact that fish properly frozen and inclosed in a protective glaze of clear ice may be shipped long distances without deterioration permits many inland communities to obtain in the winter favorite varieties taken in distant waters. Without such conservation bluefish would be on the market for only a few weeks, and then mostly in the vicinity of certain waters; salmon, unless canned or smoked, would be unknown in many sections; there would be no country-wide interchange of halibut, pike, mackerel, smelts, and other popular fish; and during the winter, when storms prevent fishing and schools of fish migrate to deep water or southward, fish of many varieties would be a costly delicacy instead of occupying their matter-of-fact place on the table.

The commercial supply of fish depends on weather conditions and on the brief periods during which certain fish appear at banks or in rivers to feed or to spawn. Much of the fish crop, therefore, is as strictly seasonal as are the harvests of most of the perishable land crops. During certain seasons fish are landed in quantities far in excess of immediate needs, and, without effective conservation, these vast temporary surpluses would go to waste. The importance of saving the surplus of spring, summer, and fall catches for later use was appreciated long before conservation by freezing became known. Each fishing season large quantities were saved, as they still are, by canning, smoking, salting, and pickling. Freezing and storage, however, has the advantage over these other methods, in that it does not alter the flavor or appearance of fish, and therefore makes available months later, in almost the natural condition, the spring or summer catches of seine or hook.

The fish-freezing plants (Pl. I, fig. 1) located at many points on our coasts and the Great Lakes, and constituting an important industry, are becoming increasingly useful as sources of nitrogenous food to make up the deficiencies in the meat supply. Their work is true food conservation. Harvests of fish, unlike land crops, add to rather than take from the fertility of our soils. Meat represents the conversion by animals of grain or other foodstuffs into another form of food. Fish, however, represent the conversion of valueless aquatic vegetation or animal material into human food, and, had merely for the labor of harvesting, they are a net gain in the food supply.

PREPARATION OF FISH.

To produce frozen fish which after several months of storage will be practically equal in food value and flavor to freshly caught fish, it is essential that they be placed in the freezing rooms as soon as possible after they leave the water. The fish should be handled as little as possible, for any bruising, breaking of the skins, or damage to fins either lessens their keeping quality or lowers the attractiveness of the fish at market. Under no circumstances should fish be allowed to become warm from the time they are caught until they are frozen. Very slight exposure to warmth causes changes in their flesh which no amount of freezing will remove.

The ideal method of freezing fish is that employed in winter in Canada and other very cold sections (Pl. I, fig. 2), where fish caught through the ice or on the edge of the ocean are allowed to freeze naturally as they leave the water. Such fish from our northern lakes, and others, like the smelt from Nova Scotia and New Brunswick, begin to freeze while they are still flopping on the ice or in the snow. These frozen fish, which commonly have twisted bodies, due to being frozen almost instantaneously while still alive, are known on the

market as "winter caught" or "naturally frozen" stock, and, when the handling subsequent to the quick freezing is such that thawing does not occur before the market is reached, they usually command a premium because of their very fine flavor. While those who freeze fish by artificial means rarely would be able to have fish delivered alive to their plants, owners of freezers should make every effort to have their fish delivered in prime condition.

LOCATION OF FREEZERS.

Fish freezers, therefore, are best located near those fishing grounds which yield a regular supply of perfectly fresh fish (Pl. II, fig. 1). If the plant is distant from the fishing ground, or if the fish can not be delivered while still cold and within three or four hours after they are taken from the water, the owner should demand that the fishermen carry in the holds of their boats cracked ice for the proper storing of the fish as they are taken. To avoid extra handling the plant should be located near the water's edge, and, if feasible, provided with mechanical conveyors which carry fish directly from the boats to the cleaning tanks (Pl. II, fig. 2).

CLEANING FISH.

Fish as they are received in the plant must be washed free from all dirt and slime in clean, cold, running water conveniently provided in long tanks. Whether the fish should be "gutted" before freezing depends upon their size and kind, and also, to some extent, upon the market to be supplied. New York and Boston, for example, prefer salmon frozen in the "round"; other sections require that the entrails be removed before freezing. In the case of bluefish and other larger fish which are heavy feeders or which eat freely of animal material, gutting before freezing seems desirable. This is true also of fish which contain much oil, especially in the liver. Fish containing much partly digested feed in the stomach or having much oil in the flesh, deteriorate more quickly than do empty or lean varieties. Gutting of smaller fish, such as butterfish, small mackerel, small weakfish, and bass, is impracticable. These fish commonly are frozen in their natural state in pans containing about 40 pounds (Pl. III, fig. 1). Larger fish, like halibut and salmon, usually are not placed in pans but are washed and frozen separately, especially on the Pacific coast, where the fish frozen are largely of these two varieties, although some black cod or "sablefish" are handled.

FREEZING FISH.

In the most successful establishments the panned fish are placed directly on the refrigerator pipes in the "sharp freezer" room the temperature of which varies from —5° to —15° F. (Pl. III, fig. 2).

These pipes are usually direct expansion pipes from the ammonia refrigerating plant. They are so arranged that they make a series of shelves one above the other, each consisting of numerous pipes. Passageways are left between each set of shelves for the convenient handling of trucks. Some plants have installed mechanical conveyors to facilitate carrying the fish to and from the fish-freezing rooms.

The operators remove the frozen fish from the pan by pouring a little cold water on the outside of the pan, which causes sufficient melting to allow the frozen fish to slip out in a block. Fish which are to be frozen separately are laid on thin metal sheets resting on the cold pipes, or they are suspended in the air from iron rods or hooks. Fish, single or panned, freeze thoroughly in from 12 to 30 hours, according to their size and the temperature of the freezing room.

FREEZING IN ICE OR IN BRINE.

The older method of freezing fish by packing them in covered pans which then are buried in ice and salt still is practiced in some districts. This plan is not adapted to freezing fish rapidly on a large scale and does not lend itself to accurate control of temperature. Methods of freezing fish in saturated salt brine, cooled to low temperatures by freezing coils, recently have been patented. The salt in brine chilled almost to its freezing point apparently does not penetrate into the fish to any great extent, and freezing is much more rapid than in air. These processes have great merit from the theoretical point of view, and appear to be adapted to commercial conditions, but as yet they have not been adopted by the trade in this country.

GLAZING.

Glazing, an important step in the freezing of fish, is designed to incase each fish or each block of frozen fish with an air-tight protective envelope or cover of clear ice. Unless glazed, the skins of frozen fish are liable to turn white and the fish themselves will shrivel because of loss of moisture which takes place even at freezing temperatures. Noses and fins of frozen fish, unless protected by glazing, are the first points to show the effect of loss of moisture. Glazing also helps to prevent the eyes of the fish from becoming opaque and shrunken and to obviate deterioration which makes the gills, which normally are bright red, darker and brownish. Glazing prevents the evaporation of the moisture from the flesh of the fish, prevents the entrance of air which tends to make the fish oils deteriorate, provides an ice surface upon which molds and fungi can not grow, and finally helps to protect the fish from mechanical injuries which mar its appearance.

For glazing, the frozen fish are taken to the glazing room, which is held at a temperature of 20° to 25° F., or just cold enough to cause thin layers of cold water to freeze rapidly. The glazers slide the frozen cakes of panned fish, or the separately frozen fish, quickly through a trough of clean, clear water held just above the freezing point. (Pl. IV, fig. 1.) This water covers the product with a thin film which in the cold air freezes instantly into a crystal-clear glaze of ice like a transparent varnish. Unless the water is changed frequently, however, it is apt to collect oils or other material from the fish which will prevent the glaze from forming evenly on all parts of the fish or give the ice coating a cloudy appearance.

Fish are passed through the water from three to five times until the several coats of glaze form a sufficiently heavy and permanent ice envelope covering the entire surface. Even before glazing the blocks of frozen fish in the pans have become solid cakes, the fish being held together by the freezing of the thin layer of water between them, and the glazing still further cements them to each other. Glazing of fish adds about 5 per cent to their weight, although this varies with the size of the fish and the number of glazings. To expedite the glazing of separately frozen fish, operators on the Pacific coast place the fish on small platforms, which are lowered by a winch into a tank of water and raised again. This process is repeated until the glaze which hermetically seals the fish and prevents deterioration is of the proper thickness.

COLD STORAGE OF FISH.

The glazed fish are taken immediately to the cold-storage rooms to be kept until sent to market. (Pl. IV, fig. 2.) These are rooms with coils of ammonia or brine pipes attached to walls and ceilings, but not arranged in the form of shelves, as in the freezing rooms.

The subject of the proper temperature for the long storage of frozen fish has been much discussed. Investigation seems to prove that ordinarily the most economical and safest temperature for holding fish is at any point from zero to 10° F., with as little variation in temperature as possible. Some plants, especially small establishments in isolated localities, try to keep their frozen fish at from —5° to +5° F., because fish held at these temperatures would not spoil quickly should an accident to the refrigerating machinery interrupt artificial refrigeration for a day or two.

In determining the temperature of the storage room, operators are cautioned not to be guided by floor temperatures alone, but to place thermometers so that readings can be taken at the top of the room, to which the warmer air naturally rises, affecting the uppermost fish. It is suggested that if the owner can not provide two or more thermometers he hang a thermometer from a pulley on the ceiling

so that he can take readings of the air at various heights, especially at and above the upper fish. Every operator, of course, understands the importance of keeping doors to cold storages closed, particularly when they open into outside air or into halls warmer than the storage rooms themselves.

PACKING FISH FOR STORAGE.

Before storage, frozen fish, especially on the Atlantic coast, commonly are placed in boxes lined with heavy Manila paper, which makes a better-looking package and gives additional protection. These boxes simplify the handling and shipping of fish, and also enable warehousemen to comply with any local laws which require that the date of entering the storage be stamped on the packages. Boxing the frozen fish before storage, by lessening the free circulation of air among the fish, helps also to prevent evaporation of the ice glaze, for ice evaporates even at freezing temperatures, as is evidenced by the gradual shrinking of a block of ice outdoors, even in zero weather. Boxed fish which have received from three to five glazings usually keep from three to five months without losing their glaze, or much longer than unboxed fish exposed to the air.

Four or five cakes of the panned fish, or 120 to 160 pounds, commonly are packed in one box, whose length and width are just large enough to take these cakes from the pans. Separately frozen fish, such as halibut, salmon, and other large fish, generally are first wrapped in a fish-wrapping paper, usually a vegetable parchment paper, and packed carefully in boxes lined with Manila paper. On the Pacific coast longer narrow boxes are used for packing halibut and salmon. While under some conditions the cheaper sorts of fish are stored in bulk, either in bins or in stacks, the boxed fish keep their glaze better and are less liable to damage from handling.

REGLAZING.

Because the glaze gradually evaporates, it is necessary, if the fish are to be kept in storage for a long time, to remove them from their boxes and reglaze them at intervals of from three to four months. Reglazing of fish stacked or kept in bins is somewhat more difficult. A method occasionally followed in reglazing such fish is to use a hose with a special spray nozzle, similar to that employed in whitewashing. The nozzle plays a finely-divided stream of clean water on the piles of frozen fish, and this, freezing rapidly, reglazes them more or less satisfactorily. The glaze naturally evaporates most rapidly from the outer surface of the pile most exposed to air, and these parts fortunately are most accessible to the reglazing spray.

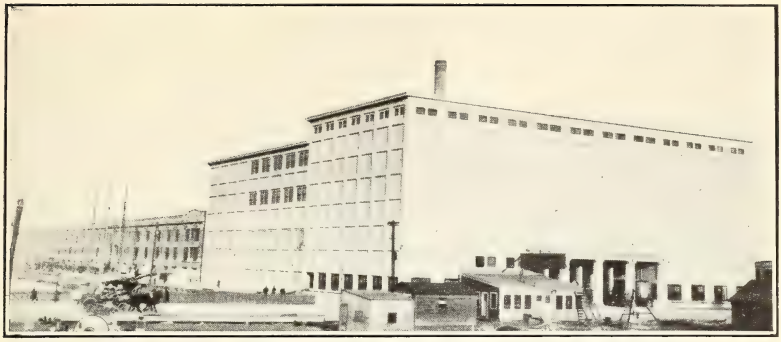

FIG. 1.—THE LARGEST FISH FREEZER IN THE UNITED STATES.
The State of Massachusetts built this freezer, which has a capacity of 15,000,000 pounds of frozen fish.

FIG. 2.—WINTER-CAUGHT, OR NATURALLY FROZEN, FISH.

FIG. 1.—NEWLY CAUGHT FISH CARRIED BY WAGON FROM BEACH TO FREEZER.

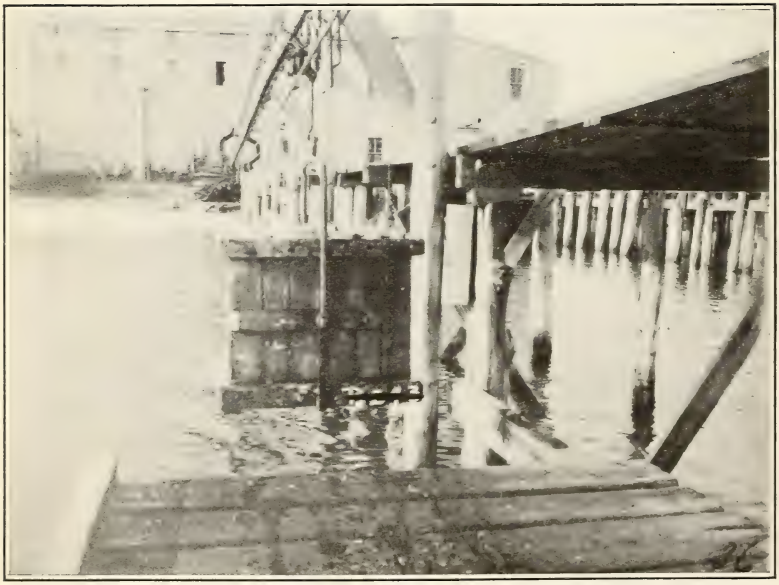

FIG. 2.—CONVEYOR CARRYING FISH FROM ICE HOLD OF BOAT TO FREEZER.

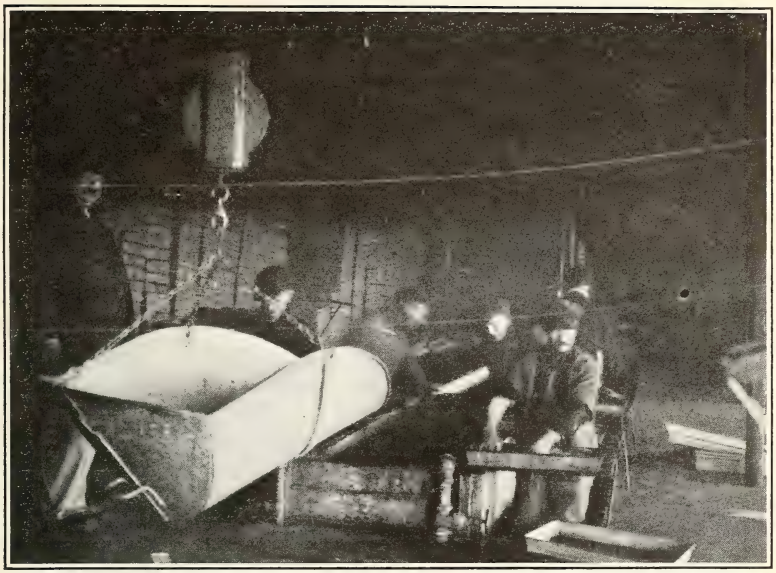

FIG. 1.—PANNING FISH, PREVIOUSLY WASHED IN LONG TANK BESIDE WHICH THE MEN ARE STANDING.

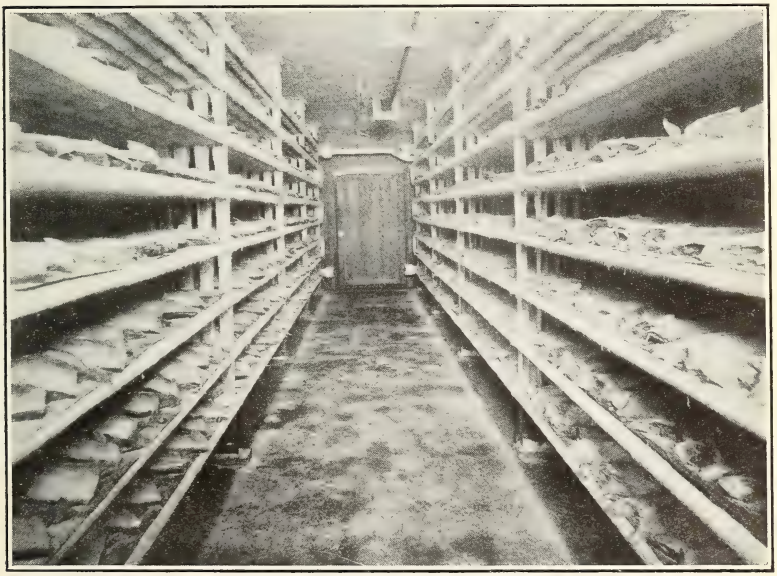

FIG. 2.—SHARP FREEZER ROOM.

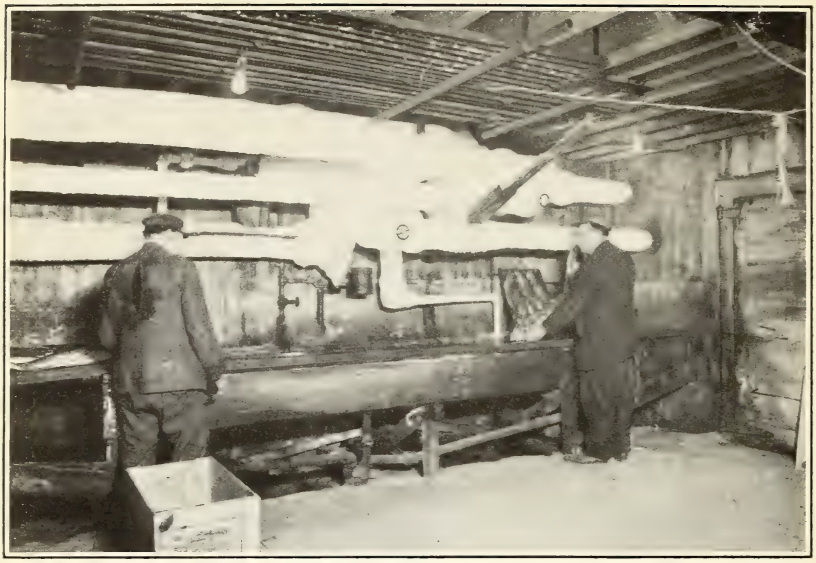

FIG. 1.—PUTTING FISH IN ICE ENVELOPES.

FIG. 2.—COLD-STORAGE ROOM. PILES OF FROZEN HALIBUT READY FOR BOXING AND SHIPMENT.

PERIOD OF STORAGE.

The average period of storage for fish, as shown by investigation and statistics, is approximately only eight months. Much frozen fish, however, is sold within a few months after it is stored, and only rarely are batches of fish held as long as twelve months. Careful analysis of fish properly stored for such periods fails to indicate any important change in the food value of the fish, or to reveal any noticeable alteration in the flavor. To study in a practical way the effect of freezing storage on flavor, one of the writers[1] arranged a test with a large group of people who were unaware that they were being used for subjects. These people were served a half portion of fresh fish (mackerel) and a half portion of the same species of fish properly frozen and stored for nine months. The average individual was unable to distinguish between the fresh fish and the frozen fish, and a number expressed a preference for the frozen lot.

In an effort to determine the natural storage limits for frozen fish, the department's investigators recently held frozen fish for twenty-seven months under close observation in a Government experimental freezer. Elaborate analyses of the fish at various time intervals and at the end of this period failed to show changes which rendered them at all unsuitable for food, or to indicate any important differences in chemical composition between these fish and fresh fish or fish stored for shorter periods. The actual period for which any batch of fish will be held in storage depends, of course, largely upon the market conditions. Only under very unusual circumstances are frozen fish held for more than one year, because the season of fresh fish of any particular species will recur in ten or twelve months, and frozen fish bring lower prices than fresh fish. Frozen fish must be marketed before fresh fish again become plentiful on the market. Other deterrents against holding fish for any great length of time are the cost of refrigeration, labor, and reglazing, insurance during storage, interest on capital, and other factors which promote withdrawal from storage as soon as a favorable market can be obtained. The legal limit on the storage of fish in several States varies from nine to twelve months, although in certain States extensions can be secured upon application to the proper authorities. Observations show, however, that only under very abnormal conditions and in unusual seasons is there either any necessity for or commercial advantage in holding fish longer than nine or ten months.

FOOD VALUE OF FROZEN FISH.

Fresh fish, properly frozen, glazed, and held at low temperatures for nine months or a year show no important changes in composition to the food chemist or bacteriologist. No lessening of palata-

[1] From unpublished investigations of L. H. Almy.

bility noticeable to the average housewife occurs. This is to be expected, as freezing, unlike most other preservative measures, takes nothing from the fish and adds nothing to it except a thin outer covering of ice which soon melts upon thawing the fish for consumption. The low temperatures at which the flesh is held in storage are well designed to prevent chemical or other changes over a number of months. Freezing, however, merely holds the fish in the condition in which it entered the freezing room. Cold can not restore freshness to old fish nor overcome deterioration from careless handling or exposure to warmth. The freezer can deliver fish practically as good as but not better than that which it receives.

To determine the behavior of fish under storage the Bureau of Chemistry held fish for the excessively long period of twenty-seven months in cold storage under its control. At different times sample lots of fish were withdrawn and analyzed. These studies showed no significant difference in composition between the frozen fish and fresh fish of the same species. Of special interest is the fact that no loss of those nitrogenous constituents which give to fish its chief food value was noted.

According to these analyses, the process of freezing and storing causes no appreciable chemical change in those constituents upon which the food values are usually calculated, even when the storage is prolonged for greater periods than are necessary or profitable in commercial practice. In some cases the chemists were able to detect after storage very slight changes in the percentage of ammonia and certain other constituents. These changes, however, affect in no way the food value of the fish, and, in fact, the differences often were not as great in the same lot of fish before and after storage as they were between two individuals of the same species when analyzed in the fresh condition.

HANDLING OF FROZEN FISH AFTER STORAGE.

When frozen fish have thawed they are as perishable as fresh fish, and should be consumed as quickly as possible. Even partial thawing lessens greatly the perfect protection of glazing and hard freezing. Retailers, therefore, should make every effort to have their frozen fish reach them hard frozen with glaze unimpaired. After the fish reach them the retailers should make very effort to keep them hard frozen and glazed until they are actually sold. This best can be accomplished by ordering frequently and not in excess of immediate sale. Customers should be encouraged to buy fish in the hard-frozen state, either to be thawed out to order by the retailer or, even better, delivered to the housewife hard frozen. She then should place them in a covered utensil in the refrigerator, or other cold place, and allow them to thaw gradually. Fish never should

be thawed by exposure to heat or by soaking in either cold or warm water. Such rapid thawing lessens their food value, and tends to dissolve out flavors essential to their palatability.

SUMMARY.

Freezing and freezer storage will hold fish for many months in the condition in which they were received, but will not repair deterioration due to previous heating or mishandling.

Freezers should accept only fish that are in prime condition. Unless delivered within three or four hours after being taken from the water, fish should be kept under refrigeration in the boats.

Rapid freezing at as low temperatures as possible is necessary in many plants in order to insure a good product and to handle receipts as they arrive.

Glazing by inclosing the fish in an envelope of ice prevents loss of moisture, protects the fish from molds and bacteria, and makes them less subject to mechanical injury. Fish to be stored for more than three to five months should be reglazed occasionally, as in time the glaze evaporates, even at low temperatures.

The most economical temperature for storing fish is probably at some constant temperature between 0° and +10° F., although some freezers hold that lower temperatures tend to delay evaporation of the glaze.

Boxing fish before storage helps to prevent loss of glaze, and protects the product from mechanical injury.

Properly frozen fish reach the retailer in excellent condition. He should keep them hard frozen until they are sold. The practice of thawing fish by warming or in water greatly lessens their food value and flavor.

Chemical analyses show no significant changes in fish held twenty-seven months, or for a period much longer than would be necessary or profitable in storing fish commercially.

PUBLICATIONS OF THE U. S. DEPARTMENT OF AGRICULTURE RELATING TO REFRIGERATION.

PUBLICATIONS AVAILABLE FOR FREE DISTRIBUTION BY THE DEPARTMENT.

Study of Preparation of Frozen and Dried Eggs in Producing Section. (Department Bulletin No. 224.)

Shrimp, Handling, Transportation, and Uses. (Department Bulletin No. 538.)

Studies of Poultry from Farm to Consumer. (Chemistry Circular No. 64.)

Practical Suggestions for Preparation of Frozen and Dried Eggs, Statement Based on Investigation Made in Producing Section During Summer of 1911. (Chemistry Circular No. 98.)

Supplementing our Meat Supply with Fish. (Separate 623 from Yearbook 1913.)

PUBLICATIONS FOR SALE BY THE SUPERINTENDENT OF DOCUMENTS, GOVERNMENT PRINTING OFFICE, WASHINGTON, D. C.

Changes in Fresh Beef During Cold-Storage, Above Freezing. (Department Bulletin No. 433.) Price, 10 cents.

Preliminary Study of Effects of Cold-Storage on Eggs, Quail, and Chickens. (Chemistry Bulletin No. 115.) Price, 40 cents.

Bacteriological Study of Shell, Frozen, and Desiccated Eggs, Made Under Laboratory Conditions at Washington, D. C. (Chemistry Bulletin No. 158.) Price, 10 cents.

Handling of Dressed Poultry a Thousand Miles from Market (Separate 591 from Yearbook 1912.) Price, 15 cents.

Shipping Fish Three Thousand Miles to Market. (Separate 665 from Yearbook 1915.) Price, 5 cents.

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